Human Health

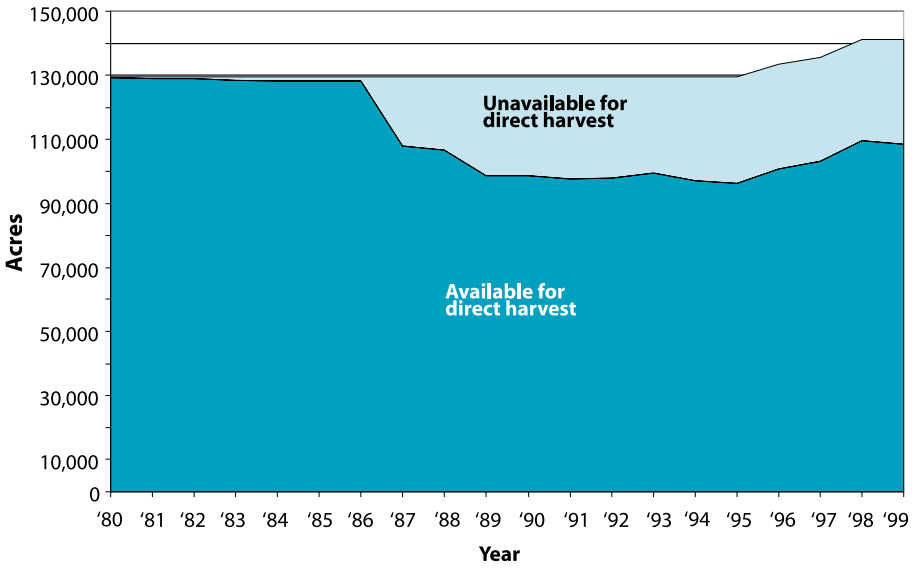
Summary

Conditions in Puget Sound can affect the health of the region's human residents. Contaminants that harm the Sound's biological resources can also threaten human health. Much of our society's concern for clean water is directed at making sure we can fish, swim and safely eat shellfish harvested in our waters. Our society addresses these concerns by developing programs and institutions to control biological and chemical contamination of our waterways from human-caused or human-controlled sources.

Contamination of Puget Sound by pathogens, nutrients and toxic substances was discussed in earlier chapters of this report. This chapter summarizes some of the human health implications of pathogen and toxic substance contamination in the Sound. It also summarizes information on naturally occurring toxic substances, such as the toxin that causes paralytic shellfish poisoning, and pathogens, such as *Vibrio parahaemolyticus*, that affect the safety of Puget Sound's shellfish as a food source.

Human health threats from Puget Sound occur primarily through consumption of shellfish and fish, rather than through contact with the water during wading, swimming or other activities. Because pathogens and toxic chemicals accumulate in shellfish and other organisms, they become more concentrated in these organisms than in the surrounding water, and therefore pose a greater risk of causing sickness. For this reason, this chapter addresses only health risks from consumption of shellfish and fish. Local health authorities may be able to provide information on human health risks related to wading, swimming and diving in contaminated areas.

Figure 44. Trend in commercial shellfish growing area in Puget Sound available for direct harvest.



Source: Department of Health.

This chapter specifically addresses: (1) the management of pathogen-related risks associated with shellfish growing and harvest, (2) the occurrence of natural toxins that threaten human health due to their concentration in shellfish, and (3) the threats posed to human health by toxic contaminants in fish.

Findings

Managing Pathogen-Related Risks from Shellfish Consumption

The Washington State Department of Health (State Health) and local health jurisdictions routinely assess water quality at commercial shellfish growing areas and at recreational shellfish harvesting areas. Health professionals use this water quality data and information from surveys of potential pollution sources to identify or "certify" areas from which shellfish can be harvested and areas where harvest must be restricted or prohibited.

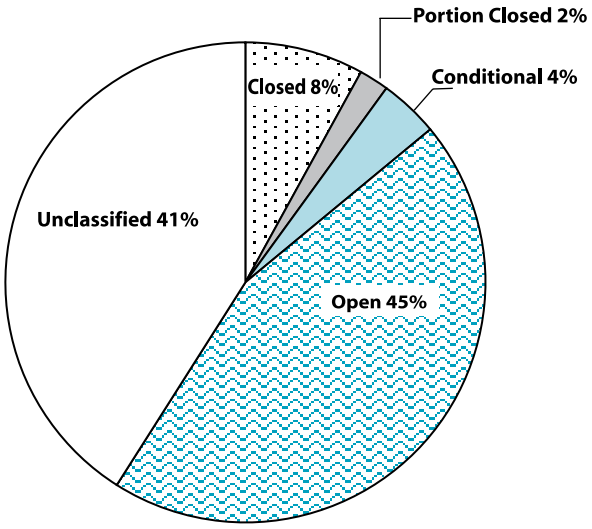
Commercial Growing Areas. State Health classifies commercial shellfish growing areas throughout Puget Sound according to each area's ability to produce shellfish that are safe for human consumption. Historically, about 136,000 acres of Puget Sound tidelands have been utilized for commercial shellfish production. Approximately 75 percent of this area is currently approved for direct harvest and marketing of shellfish. Figure 44 shows how much commercial shellfish growing acreage in Puget Sound was available in 1998 for direct harvest of shellfish (i.e., the acreage classified as "approved" or "conditionally approved" by State Health's shellfish program).

Recreational Shellfish Harvest at Public Beaches. Local health jurisdictions and State Health shellfish programs work together to evaluate public beaches to determine which areas should be opened to recreational harvest and which areas should be closed. Department of Fish and Wildlife staff estimate that nearly 250,000 residents and visitors harvested shellfish from Puget Sound public beaches in 1998. Figure 45 shows that approximately 50 percent of recreational harvest in 1998 occurred in areas that were classified as open or conditionally open for harvest. Unfortunately, eight percent of the harvest occurred at beaches classified as closed. Just over 40 percent of the harvest occurred at beaches that have not been evaluated and classified. State Health will classify the remaining recreational beaches as time and resources allow.

Safeguards on human health

Our society has developed safeguards to limit risks to human health from exposures to harmful agents in the environment. Laws and government programs have been developed to ensure the safety of food and to protect against environmental contamination. In many cases, these laws and programs work by restricting or curtailing human uses of resources from waterways, such as Puget Sound, for food supply or recreational opportunity. Many of the results presented in this chapter focus on these restrictions.

***Vibrio parahaemolyticus* in Puget Sound.** The Department of Health began regular monitoring of shellfish meat for *Vibrio* bacteria after an outbreak of illnesses in 1997. The department closes growing areas to shellfish harvest when *Vibrio* levels exceed 10,000 micrograms of *V. parahaemolyticus* bacteria per gram of shellfish meat. Lower levels of contamination and outbreaks of *Vibrio*-related illness have led State Health to recommend that industry voluntarily restrict harvest and include "cook thoroughly" labels on shellfish products.



Source: Department of Health

Figure 45. Recreational shellfish beach classifications.

Percent of harvesters observed in 1998 at beaches in each classification.

Over 30 species of *Vibrio* bacteria occur naturally in marine waters, estuaries, lakes and ponds worldwide. Ten of these species are known to cause gastrointestinal illness. *Vibrio* infection has been directly related to eating raw or partially cooked seafood that has accumulated the bacteria, particularly during warm summer months. The species of greatest concern in Puget Sound is *Vibrio parahaemolyticus*.

The highest levels of *V. parahaemolyticus* occur in shellfish that are exposed during mid-summer low tides when water and air temperatures are highest. Not surprisingly, this period coincides with the greatest number of *Vibrio*-related illnesses (vibriosis). The largest local vibriosis outbreak on record occurred in the summer of 1997, when 58 confirmed cases that were strongly linked to Washington molluscan shellfish were reported by the end of September. Prior to 1997, confirmed cases ranged from two to 32 per year.

During the summer of 1998, 48 shellfish-related *Vibrio* illnesses were reported to the Department of Health, only slightly fewer than the year before.

- Two-thirds of these cases were from commercial products and the remaining one-third were from recreationally harvested shellfish.
- Two-thirds of the cases were linked to shellfish harvested from various parts of Hood Canal, including Quilcene and Dabob bays. Four cases were linked to Samish Bay. The remaining 12 cases were linked to areas in south Puget Sound, Birch Bay (Strait of Georgia) and Willapa Bay (Coast).
- Nearly three-quarters of the cases were linked to consumption of raw oysters (30 to shellstock oysters and five to shucked oysters). The remaining cases were linked to consumption of cooked shellstock oysters (five cases), steamed clams one case) and multiple shellfish and seafood products (seven cases).

In 1999, only 14 confirmed cases of vibriosis linked to Washington shellfish occurred through September. All were linked to oysters. An additional eight confirmed cases were linked to oysters served in restaurants that serve shellfish from numerous areas, including Washington.

Pollution sources limit areas suitable for shellfish harvest

The information presented on the previous page about Puget Sound's shellfish growing areas does not address the Sound's east shore from Everett to Tacoma. Potential harvest areas in this portion of central Puget Sound, and in other heavily urbanized areas, cannot be certified because commercial shellfish harvesting is prohibited near potential pollution sources. Authorities recommend against recreational harvest in this area because of the presence of many potential sources of pollution.

Table 11. Peak counts of* Vibrio parahaemolyticus *as measured in 1998 at five Washington shellfish growing areas.

Date in 1998	Growing Area	Maximum *Vibrio* Concentration (µg/g shellfish tissue)
June 29	Samish Bay (north Puget Sound)	1,100
July 27-September 8	Totten Inlet (south Puget Sound)	24,000 (seen several times)
August 4	Rocky Bay (Case Inlet—central Puget Sound)	2,400
August 4	Quilcene Bay (Hood Canal)	24,000
August 8	Willapa Bay (coast)	43

After the 1997 outbreak, State Health staff began year-round monitoring of *V. parahaemolyticus* in five growing areas implicated as sources of contaminated shellfish. These areas were: Samish Bay (north Puget Sound), Quilcene Bay (Hood Canal), Totten Inlet and Rocky Bay (both in south Puget Sound), and Willapa Bay (on the coast). Monitoring was suspended for the season in November 1999 after *V. parahaemolyticus* dropped to undetectable levels.

Oyster samples collected from late 1997 through the spring of 1998 had non-detectable or extremely low levels of V. parahaemolyticus. Except for a few sporadic samples collected in May and June 1998, levels remained low (below 100 micrograms (µg) of bacteria per gram (g) of oyster tissue) until July of 1998. The levels increased rapidly in July but dropped again to non-detectable or extremely low levels by the end of September. The highest levels of bacteria found in each monitoring area during 1998 are shown in Table 11.

In 1999, monitoring from commercial shellfish growing areas indicated that summertime levels of *V. parahaemolyticus* were low compared to those in 1998. Only Hood Canal had *Vibrio* levels above 100 micrograms per gram of oyster tissue. The highest level of *Vibrio parahaemolyticus* detected in 1999 (1,100 µg/g) was in a sample from Quilcene Bay in July.

Vibrio-induced illness

Vibrio bacteria have been isolated from virtually every geographic area in the United States; the most frequently observed species include *V. cholerae, V. vulnificus*, and *V. parahaemolyticus*. The first two species can cause life-threatening illness or death. Historically, *Vibrio cholerae* (cholera) has been particularly devastating, especially in the third world. Although morbidity can run quite high in areas affected by cholera, the fatality rate can be less than one percent with proper diagnosis and treatment. Both *V. cholerae* and *V. vulnificus* can cause septicemia and ulcerating sores in persons with pre-existing health problems such as liver impairment or a suppressed immune system. Gastroenteritis is the chief complaint associated with *V. parahaemolyticus* infection. Symptoms include diarrhea, abdominal cramps, nausea and vomiting. Rarely, *V. parahaemolyticus* may be involved with infections outside the gastrointestinal tract at the site of a recent injury.

Biotoxins in Shellfish

Since 1957, the Department of Health has regularly monitored paralytic shellfish poison (PSP) and other biotoxins that accumulate in shellfish. The department closes an area to shellfish harvest when PSP levels in the local shellfish equal or exceed 80 µg of toxin per 100 g of shellfish meat—the safety level set by the U.S. Food and Drug Administration (FDA).

In Washington, PSP is produced by the dinoflagellate *Alexandrium catenella.* In other parts of the world, different species produce PSP. Blooms of *Alexandrium* are seasonal, tending to begin in spring and often extending well into fall.

To protect shellfish consumers, scientists from State Health monitor PSP in a number of shellfish species at many locations in Washington's marine waters. A portion of this monitoring effort, called the "Sentinel Biotoxins Program," provides early warning of the onset of toxic events based on the sampling of mussels every two weeks at over 40 sites.

In 1999, Department of Health scientists examined monitoring results from 33 sites in Puget Sound, the Strait of Juan de Fuca and the Strait of Georgia. Using these data, they calculated the duration (in days) that PSP concentrations in shellfish samples from each site exceeded the FDA standard.

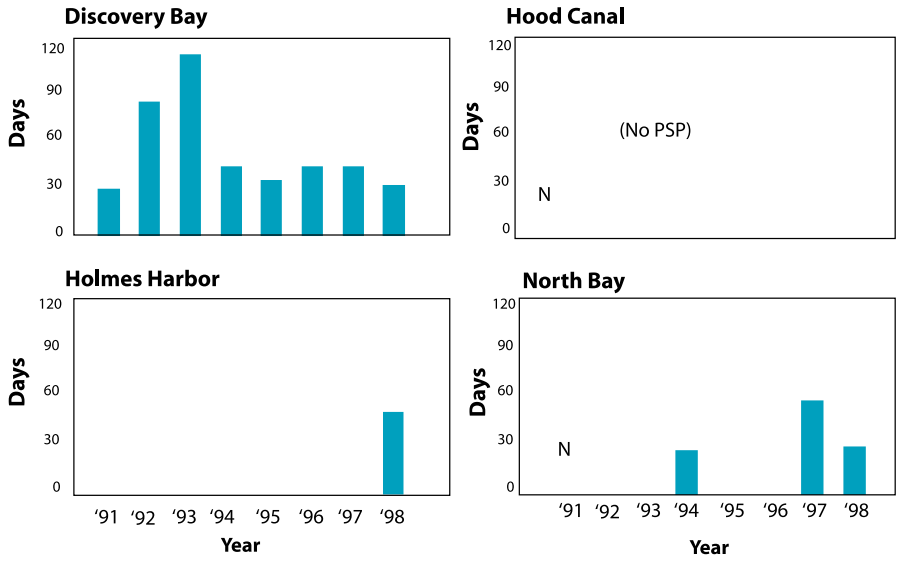


Figure 46. Year-to-year patterns of paralytic shellfish poisoning (PSP) toxic impact at selected locations in Puget Sound.

"N" indicates that insufficient data were available to calculate PSP toxic impact for that year.

Figure 46 shows four patterns of year-to-year variability in the annual duration of PSP concentrations above the FDA standard. From 1991 to 1998, a number of stations showed consistently high impacts from PSP as shown in Figure 46 for Discovery Bay. Other locations exhibiting this pattern of PSP toxic impact include Sequim Bay, Mystery Bay (Marrowstone Island), Quartermaster Harbor (Vashon Island) and Miller Bay (Kitsap Peninsula). Stations in southern Hood Canal had no PSP problems from 1991 to 1998, while stations farther north in the canal showed rare, limited PSP impacts. Stations at Holmes Harbor and Penn Cove (on the east shore of Whidbey Island) showed no PSP problems from the 1970s until 1998. A number of south Puget Sound stations showed sporadic impacts in the early 1990s followed by a sustained toxic event from late 1997 to early 1998, as shown in Figure 46 for North Bay (Case Inlet). This pattern was also observed at other south Sound locations including Jarrell Cove, Johnson Point, Filucy Bay and Steilacoom.

Year-to-year variations at all 33 stations evaluated by Department of Health staff showed that nearly one-half of stations experienced shorter periods of toxicity in 1998 than in 1997, and only one-fifth of stations had longer toxic periods. The remaining nine stations had no PSP problems in either year. This indicates that PSP toxicity in Puget Sound in 1998 was less severe than it was in 1997.

Figure 47 (page 74) shows the total duration of PSP toxic impacts observed from 1996 through 1998. Four categories of PSP impact for the period from 1996 to 1998 were defined as follows:

- **high-impact:** where the total duration was greater than 90 days;
- **moderate-impact:** where the total duration was between 31 and 80 days;
- **low-impact:** where the total duration was one to 30 days; and
- **no-impact:** where no PSP measurements above the FDA standard were recorded.

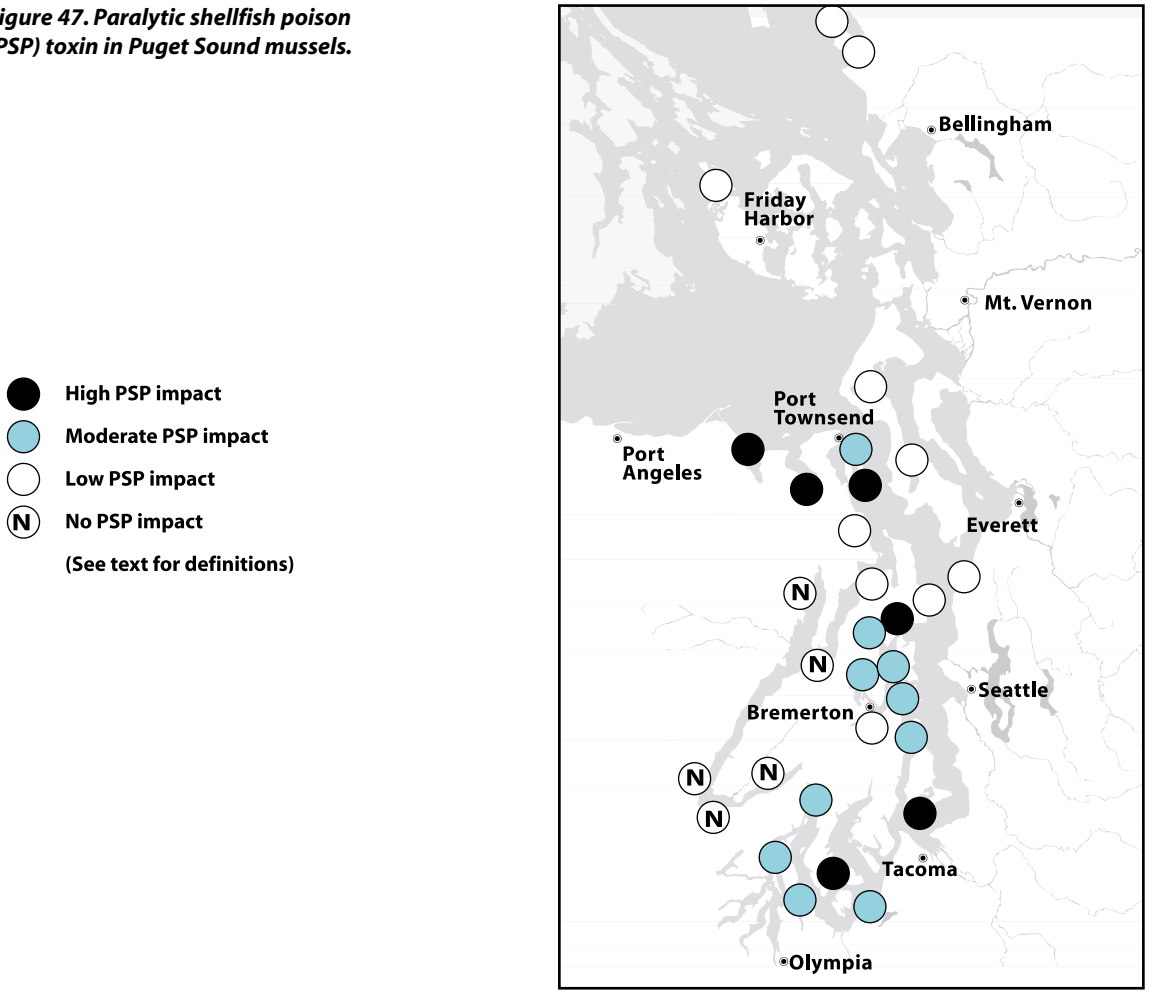
Hunter and Shoal bays in the San Juan Islands were sampled inconsistently in 1998 and could not be assigned a PSP impact category.

Figure 47 indicates that six locations in Puget Sound registered high PSP impact from 1996 to 1998: Sequim, Discovery and Mystery bays on the Strait of Juan de Fuca;

Paralytic Shellfish Poison

PSP is actually a family of related chemicals called saxitoxins that interfere with nerve function in warm-blooded animals. The primary symptoms of PSP are numbness and tingling of the lips, tongue, face and extremities; difficulty talking, breathing and swallowing; loss of muscular coordination; and paralysis. PSP can lead to death if it paralyzes the respiratory system. Symptoms develop quickly, usually within an hour or two after eating PSP-contaminated shellfish. There is no known antidote.

Figure 47. Paralytic shellfish poison (PSP) toxin in Puget Sound mussels.



Source: Department of Health

Miller Bay (Kitsap Peninsula) and Quartermaster Harbor (Vashon Island) in Puget Sound's main basin; and Filucy Bay in south Puget Sound. The observed geographic pattern of PSP impact in Puget Sound has not been explained, but, factors being considered include:

- Land use—the watersheds of the six "high-impact" locations are mainly rural in character. This observation argues against the theory that increased nutrient loadings from developed lands might be an important factor contributing to toxic algae blooms.
- Hydrographic characteristics-an interaction of physical characteristics including narrow entrances, distance from entrance, shallowness, etc. that might limit flushing and induce water column stratification appears to partially describe the bays with high PSP impact. However, hydrographic features alone do not explain PSP impact; some bays with high PSP impact share similar features to those with lower PSP impact (e.g., Lynch Cove, Quilcene Bay, Drayton Harbor, Liberty Bay and Penn Cove).

Even in areas with similar characteristics, PSP impacts were different. For example, Westcott and Hunter bays are near each other in the San Juan Islands and are similar in form and upland activity; yet, PSP impact was very different at these locations.

A PSP toxic event that occurred in late 1997 and early 1998 illustrates some of the complexities that affect PSP events in Puget Sound. The impact of this event was far

Shellfish physiology and PSP

Shellfish physiology may have affected the length of the late 1997 toxic event in south Puget Sound. Mussels generally had higher levels of PSP than any other shellfish species at the same location, probably due to higher filtration rates. Dropping water temperatures late in the event probably reduced the rates at which shellfish could purge PSP from their tissues. This may have caused the duration of shellfish PSP impact to extend well beyond the time of the *Alexandrium* bloom.

greater in south Puget Sound and the coastal bays (Willapa Bay and Grays Harbor) than anywhere north of this general latitude. Localized heavy rainfall in south Puget Sound followed by region-wide fair weather in late 1997 may have promoted a late-season bloom. Shellfish from the western inlets (Totten, Skookum and Hammersley inlets and Oakland Bay) of south Puget Sound remained free of PSP impacts while levels were consistently high elsewhere in south Puget Sound (Figure 48). This pattern suggests that water circulation patterns may have influenced the distribution of the *Alexandrium* bloom and the resulting PSP toxin. This event also mirrored the 1996-1998 region-wide pattern of high impacts in rural areas (North Bay) and lesser impacts in urban areas (Budd Inlet at Olympia).

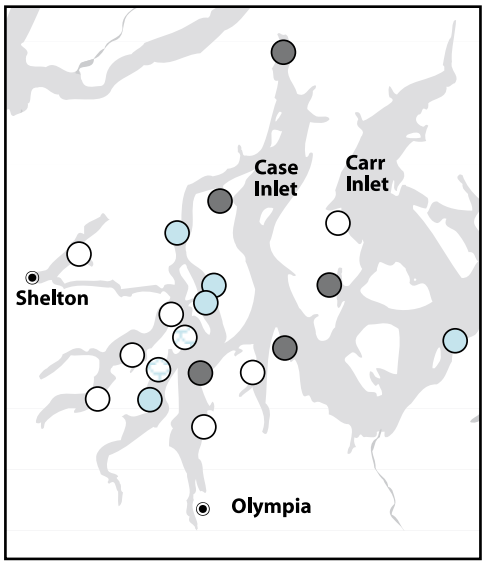


Figure 48. Maximum paralytic shellfish poisoning (PSP) levels in mussels collected at various sites in south Puget Sound from October 1997 - January 1998.

Below 80 micrograms PSP per 100 grams.

80 - 500 micrograms PSP per 100 grams.

500-1,000 micrograms PSP per 100 grams.

Above 1,000 micrograms PSP per 100 grams.

Toxic Contaminants in Fish and Shellfish

Health Risk Assessments and Consumption Advisories for Puget Sound Fish. Data on toxic chemical contamination in fish and shellfish allow Puget Sound scientists to document spatial and temporal trends in contamination (see pages 54 to 64). These data can also be used to evaluate the safety of Puget Sound seafood for human consumption. The PSAMP's fish contaminant data, collected by the Department of Fish and Wildlife, have been used as the basis for a consumption advisory for rockfish from Sinclair Inlet, to develop a model for sediment quality standards protective of human health, and to provide data for risk assessment of consuming seafood from various Puget Sound locations.

Department of Health scientists are currently evaluating fish contaminant data from the PSAMP to assess human health risks from the consumption of Puget Sound fish contaminated with mercury and PCBs. These assessments will incorporate information on the toxicity of the contaminants and estimates of fish consumption by various segments of the population. It will also consider duration of exposure to the contaminants. Reports on State Health's assessments should be available in 2000.

As shown in Table 12, scientists from State Health have identified seven fish and shellfish consumption advisories related to toxic chemical contamination in various locations around Puget Sound.

Consumption of Seafood from the Duwamish River and Elliott Bay. King County scientists assessed human health risks from the consumption of seafood as part of King County's February 1999 Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay. Scientists estimated the potential risks incurred from the consumption of Duwamish River and Elliott Bay seafood, which is contaminated with high levels of PCBs and arsenic, among other chemicals. Estimated risks from human exposure to arsenic from consumption of Duwamish River and Elliot Bay fish were about the same as risks from exposure to arsenic in seafood from Puget Sound reference sites.

Table 12. 1998 Puget Sound fish and shellfish consumption advisories due to toxic chemical contamination.

Location of advisory	Agency that issued advisory	Fish and shellfish affected	Contaminants identified
Budd Inlet, Olympia	Thurston County Health Department	Shellfish	Creosote, volatile organic compounds, pentachlorophenol and dioxins
Commencement Bay waterways, Tacoma	Tacoma-Pierce County Health Department	Bottom fish and crab	PCBs, a phthalate and tetrachloroethylene
Dogfish Bay, Keyport	Bremerton-Kitsap County Health District	Shellfish and bottom fish	Metals and vinyl chloride
Dyes and Sinclair inlets, Bremerton	Bremerton-Kitsap County Health District	Rockfish, crab, shellfish and bottom fish	PAHs and mercury
Eagle Harbor, Winslow (Bainbridge Island)	Bremerton-Kitsap County Health District	Shellfish, crab and bottom fish	PAHs and mercury
Indian Island, Jefferson County	U.S. Navy	Shellfish	Pesticides, PCBs and metals
King County marine waters, Seattle and vicinity	Seattle-King County Department of Public Health	Bottom fish, crab and shellfish	Contamination associated with historic industrial discharges

Source: G. Patrick, personal communication

Table 13. Summary of predicted cancer risks from exposure to PCBs and arsenic in seafood from the Duwamish River and Elliott Bay.

Consumption Frequency	Range of Predicted Cancer Risks
Every day (365 meals/year)	1 in 10,000 to 2 in 100
Twice per month (24 meals/year)	2 in 1,000,000 to 2 in 10,000
Once every 6 weeks (8 meals/year)	Less than 1 in 1,000,000 to 1 in 100,000

Source: King County Department of Natural Resources

A King County fishing survey identified 450 people who have eaten seafood from the Duwamish River or Elliot Bay. Seven of these people reported that they eat seafood from this area every day of the year. About one-fourth of these 450 people eat seafood from the area more than 24 times per year. About one-half of the 450 people consume seafood from the river or bay eight or fewer times per year.

Relatively high lifetime risks of developing cancer from exposure to arsenic and PCBs were predicted for people who eat seafood every day from the Duwamish River or Elliott Bay (Table 13). Lower risks were predicted for people who eat seafood from the river or bay twice per month or once every six weeks. Cancer risks from consumption of PCBs in English sole are about 20 times higher in the Duwamish River than in Elliott Bay and nearly 10 times higher in Elliott Bay than in reference Puget Sound sites. In general, predicted risks from eating salmon were lower than risks from eating other fish species.

Other types of health concerns from exposure to PCBs and arsenic were also predicted for people who eat seafood from the Duwamish River and Elliott Bay every day. Examples include effects on the neurological system, immune system and skin.

Acting on the Findings

The information presented in this chapter suggests a number of recommendations for further scientific study and/or public health management:

- Efforts to monitor water quality conditions at beaches where recreational shellfish harvest occurs should be stepped up to ensure

that residents and visitors can make informed decisions about where they might harvest shellfish that is safe for consumption.

- Additional informational and educational materials should be made available to the public to increase awareness of health professionals' advice about the recreational harvest of shellfish from public beaches and the preparation of shellfish from areas that may be affected by *Vibrio parahaemolyticus*.
- Additional research and analysis are needed to improve the understanding of environmental factors that influence the distribution and timing of PSP and *Vibrio parahaemolyticus* contamination events.
- Efforts to develop consumption advice for Puget Sound fish should be completed and a system developed to ensure that advice is available to the public.